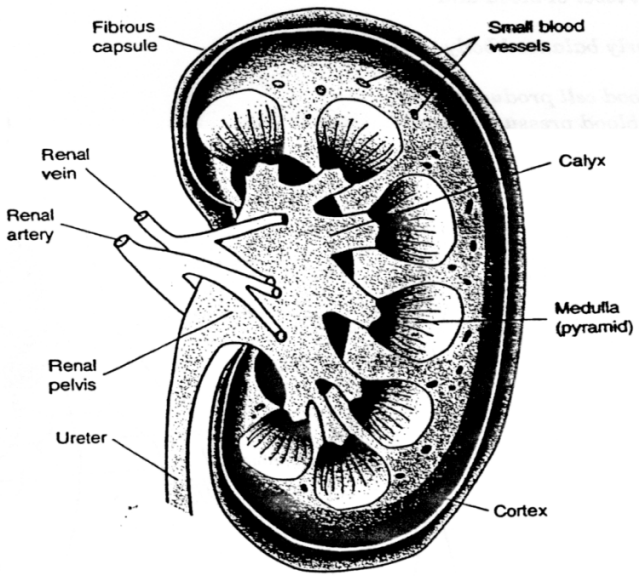
Renal Replacement Therapy

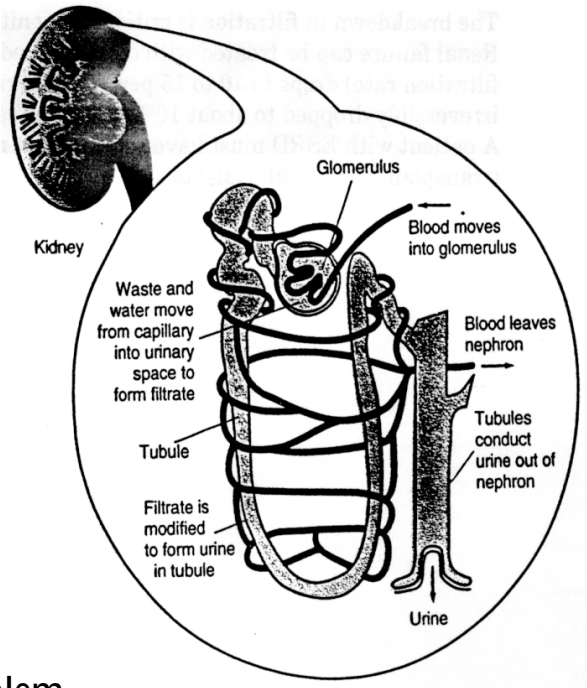
*Dr. Faraz Azim Niaz **/05/08*

When we speak about Renal replacement therapy, we mean :
Heamodyalsis, Peritoneal dialysis, Kidney transplantation

The Kidney:

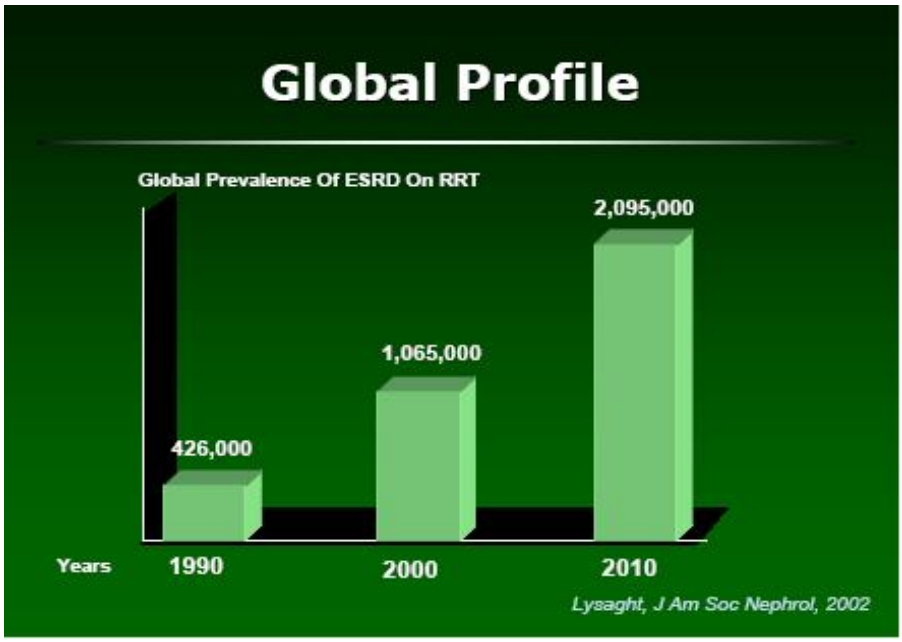


The Glomerulus:



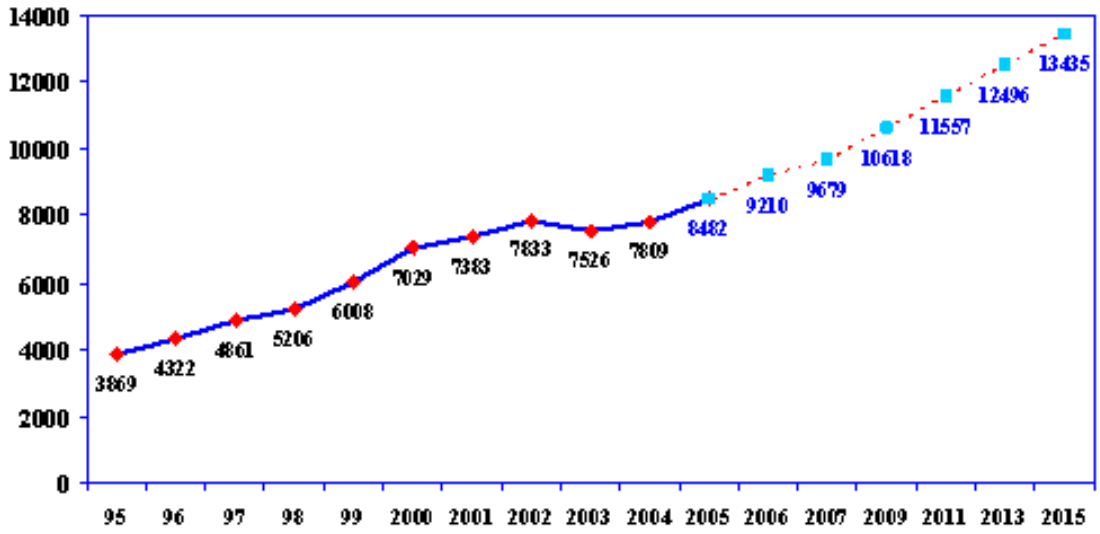
Background:

- ESRD is a globally rising health problem.
- Incidence is increasing mainly because of high prevalence of DM and increased aging.



Every 10 years, number of pts needing Renal Replacement Therapy is **doubling**.

End Stage Renal Disease (on HD) in KSA (SCOT)



Average percentage of Annual Increase = 8.3%

Number of patients requiring Renal Replacement Therapy (RRT) are growing at a dramatic rate exceeding the capacity of haemodialysis unit and transplant program.

Causes of Renal Failure:

- Diabetes
- Hypertension
- Glomerulonephritis
- Infectious Diseases
- Inherited Disease
- Drug Toxicity
- Other
- **Hereditary:**
  - APCKD. = *Autosomal dominant Poly Cystic Kidney Disease, and it is the most common hereditary disease causing ESRD*
  - Alports syndrome.
  - Medullary cystic disease of kidney.

Diabetes and its complications are the most common cause of ESRD, then Hypertension

Types of Renal Failure:

- **Acute:**
  - Sudden Onset
  - Short Duration
  - Reversible
  - Aggressive Dialysis or Conservative Management

Pts with ARF may need RRT but for short time

- **Chronic:**
  - Gradual Onset.
  - Not Reversible.
  - Prior to End Stage Conservative Management.
  - End Stage, Chronic Management.

The Initial Assessment Objectives:

- To Confirm The Primary Renal Diagnosis:
  a. **Conditions that can be arrested/reversed.**
  b. **Conditions affecting dialysis/transplantation.**
  c. **Conditions FORESEE. Genetic counseling/screening.**
- To Establish Chronicity.
- To Identify Reversible Factors.
- To Detect Intercurrent Illness.
- To Detect Comorbid Factors.
- To Establish A Baseline Database.

Reversible factors for Renal function deterioration:

1. Infection
2. Obstruction
3. Extra-Cellular Fluid (ECF) Volume depletion
4. Nephrotoxic Agents
5. Congestive heart failure
6. Hypertension
7. Pericardial temponade
8. Hypercalcemia
9. Hyperurecemia
10. Hypokalemia

Functions of Kidneys:

- Electrolyte Balance: Na–K---H
- Fluid Balance.
- Acid base Balance.
- Excretion of waste products and Drugs.
- Hormonal Secretion:

  Erythropoetin
  Renin
  Active Vit D ⇒ D3

Complications of Renal Failure:

- Electrolyte Imbalance
- Sodium Retention/Fluid Accumulation
- Hypertension
- Dyspnoea
- Anemia
- Acidosis
- Uraemic Syndrome

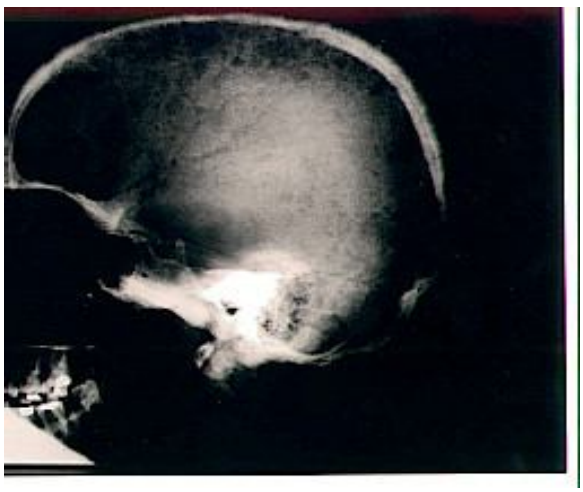
Uraemic Syndrome:

- **Symptoms**
  - GI Manifestations: (*Loss of Appetite, Nausea, Change in Taste*)
  - Neurological: (*Fatigue, Sleep Disorders, Mental Changes, Neuropathy*)
  - Hematological: (*Anemia*)
  - Dermal: (*Itching*)
  - Respiratory: (*Acidosis, Shortness of Breath*)
- **Signs**
  - BUN and ↑Creatinine.

Pictures: *(Better to see them in the PDF version OR the slides themselves)*

Uraemic Pruritis

Renal Osteodystrophy



Pepper pot Skull

Metastatic Calcification

Chronic Kidney Disease - Stages

Stage	Description	GFR (ml/min/1.73 m^2)
1	Kidney Damage with Normal or ↑ GFR	>90
2	Mild ↓ GFR	60-89
3	Moderate ↓ GFR	30-59
4	Severe ↓ GFR	15-29
5	Kidney Failure	<15 or Dialysis

Adapted from Am J KidneyDis 2002; 39 (2.Suppl. 1): S46-S75

We classify chronic kidney disease according to GFR into 5 stages.
Each stage has its management.

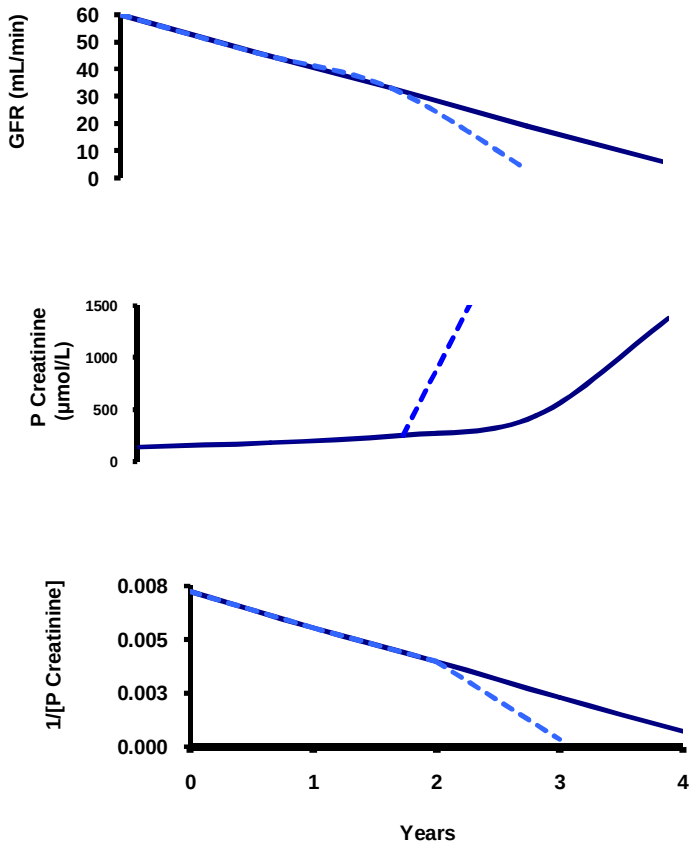
Summary
Clinical Action Plan for Chronic Kidney Disease

Stage	Description	GFR (ml/min/1.73 m^2)	Action Plan (build at each stage)
	At Increased Risk	>90 (CKD Risk Factors)	Screening, CKD Risk Reduction
1	Kidney Damage with Normal or ↑ GFR	>90	Diagnosis and Treatment, Slowing Progression CVD Risk Reduction
2	Mild ↓ GFR	60-89	Estimating Progression
3	Moderate ↓ GFR	30-59	Evaluating and Treating Complications
4	Severe ↓ GFR	15-29	Preparation for Kidney Replacement Therapy
5	Kidney Failure	<15 or Dialysis	Replacement, if Uraemia Present

Adapted from Am J KidDis 2002; 39 (No 2,suppl.1): S17-S31

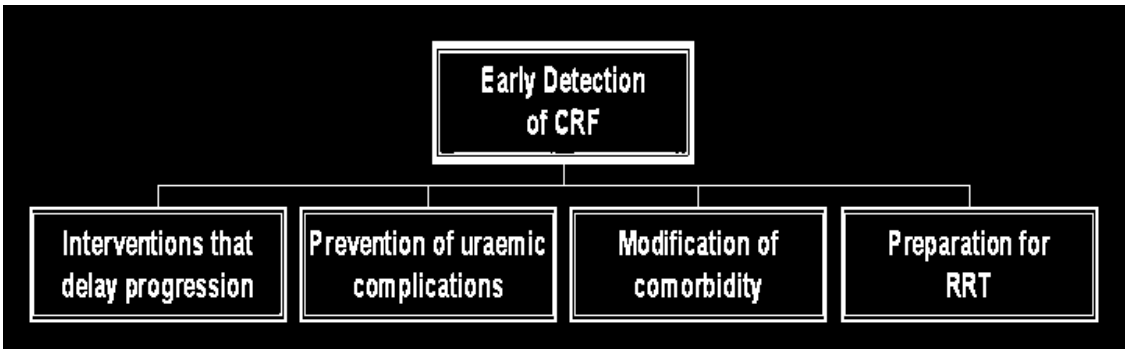
*At stage 4 we start to educate pts abut renal replacement therapy and prepare them for it. (screening the family for possible matching for renal transplantation)
*At stage 5 we start RRT.

Monitoring Chronic Renal Failure:

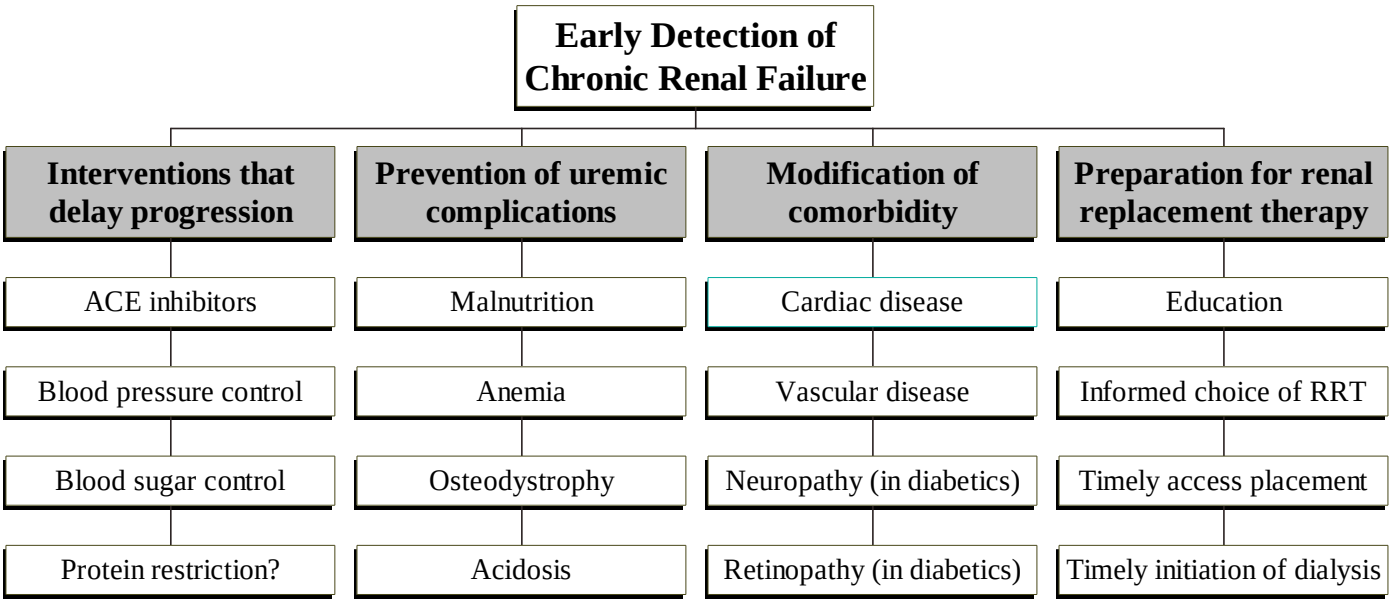


- GFR is proportional to 1/[Plasma (P) creatinine].
- Steady loss of GFR = rectilinear plot of 1/[P creatinine]
- Useful to for monitoring progress as plot declines in a predictable way
- Rapid changes can occur (—)

Care Goals for CDK Programs:



Optimal Pre-ESRD Care:



9 A's of CKD:

- Atherosclerosis
- Anti-angiotensin therapy
- Albumin
- Anions and Cations
- Arterial Blood Pressure
- Arterial Calcification
- Access
- Avoidance of Nephrotoxic Drugs
- Allograft

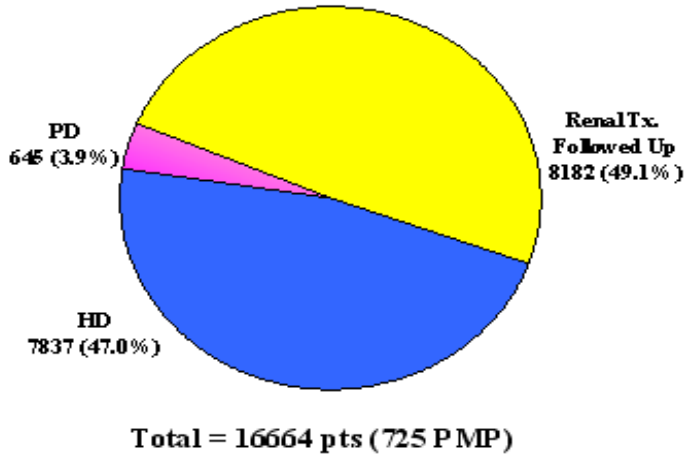
Indications for dialysis:

- CHF ; **Fluid Overload** $\Rightarrow$ resistant to diuretics.
- **Hyperkalemia** $\Rightarrow$ resistant to therapy.
- Uraemic symptoms $\Rightarrow$ encephalopathy
- Severe Acidosis (low HCO_3 <12)
- Pericarditis (+ve friction rub)
- Malnutrition – severe.

Management of End Stage Renal Disease:

- Conservative Management
- Peritoneal Dialysis
  - » CAPD, APD, NIPD, DAPD
- Hemodialysis
- Transplantation

Distribution Of RRT in KSA (SCOT 2005):



Renal Tx = Renal transplantation
HD = heamodialysis
PD = peritoneal dialysis
Low percentage of people in KSA using PD doesn't mean that PD is not effective, it has the same efficacy of HD.

Haemodialysis:

Advantages:

- Effective method to remove waste products
- Performed by trained professionals
- Provides socialization for Patients
- Only need dialysis 3 times/week.
- No equipment in the home (Unless Home HD)

Disadvantages:

- **Physical ups and downs.**
- **Use of needles.**
- **Dietary restrictions.**
- **Vascular access.**
- **Travel to Center.**

Peritoneal Dialysis:

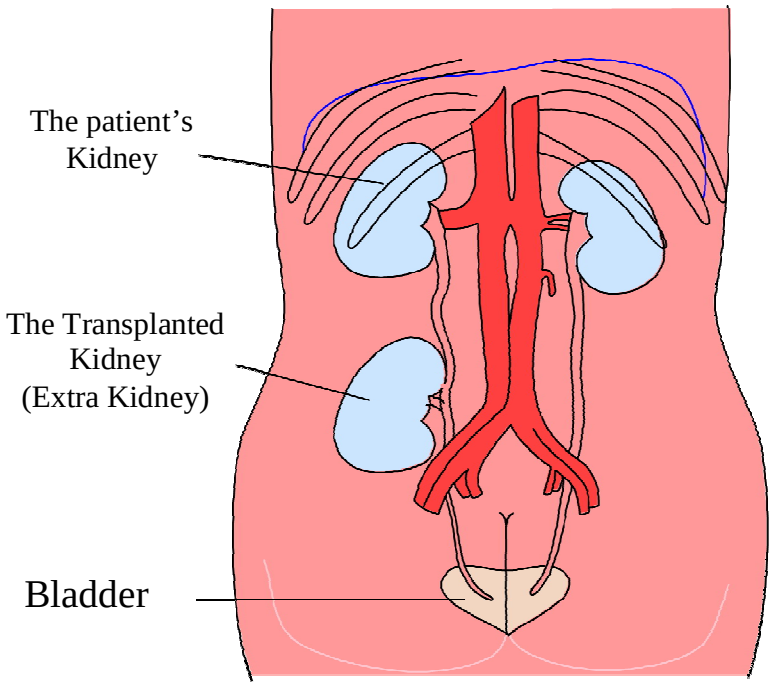
Advantages:

- Manage your own care at home.
- Greater independence and control.
- Flexible treatment schedule.
- Less restricted diet.
- No needles.
- Less stress on body.
- Blood pressure control.

Disadvantages:

- Dialysis every day.
- Permanent catheter.
- Body image changes.
- Risk of infection.
- Possible weight gain.
- Storage space needed for supplies.

Transplantation:



Advantages:

- Most like your own kidney
- No dialysis needed
- No access needed
- Normal Diet (-sodium)
- More "normal" life style

Disadvantages:

- Risks of major surgery.
- Risk of body rejecting kidney.
- Possible side effects of drugs.
- Lower resistance to illness.

Aims of Dialysis:

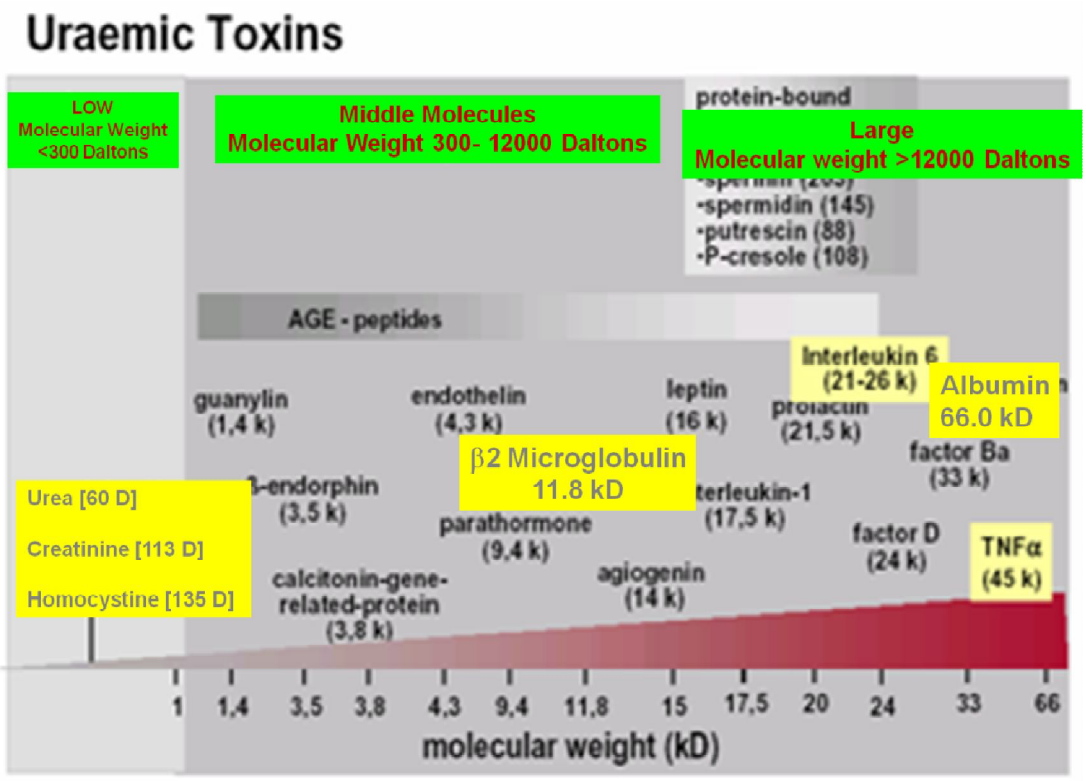
- Toxins and Solute removal from the Patient when:
  - GFR <15 ml/min Diabetic
  - GFR < 10 ml/min Non-Diabetic
  - Resistent Hyperkalemia
  - Persistent Itching
  - Symptoms of uremia
- Transfer of Solutes to the Patient.
- Removal of water from the Anuric or Fluid overloaded patient.

Factors Influencing Solute Removal:

- Machine
- Dialyzer
- Access
- Dialysate
- Time on dialysis
- Molecular weight of the solute

Molecular Weight:

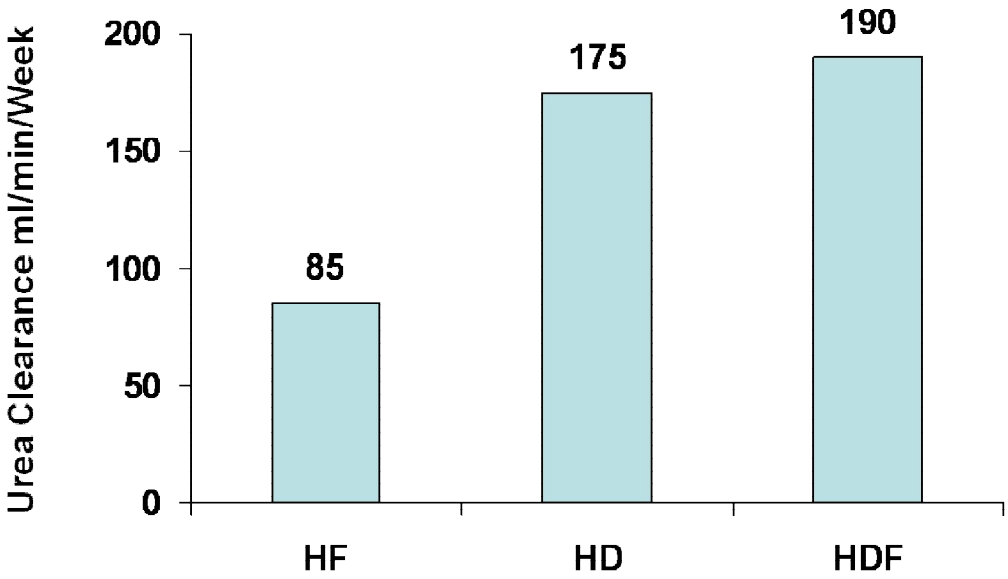
- Small molecular substances:
  - Urea [60], Creatinine [113] need small pores so low flux dialyzers & diffusion.
  - [Hemodialysis] most effective way
- **Middle molecules [β_2 Microglobulin]**
  - >300 –12000 need larger pores & Convection.
  - [Hemofiltration or Hemodiafiltration] most effective way



Modes of therapy:

- Hemodialysis – HD
- Hemofiltration – HF
- Hemodiafiltration – HDF
- Continuous Renal Replacement Therapy – CRRT
- Isolated Ultrafiltration – UF

Urea Clearance ml/min/week

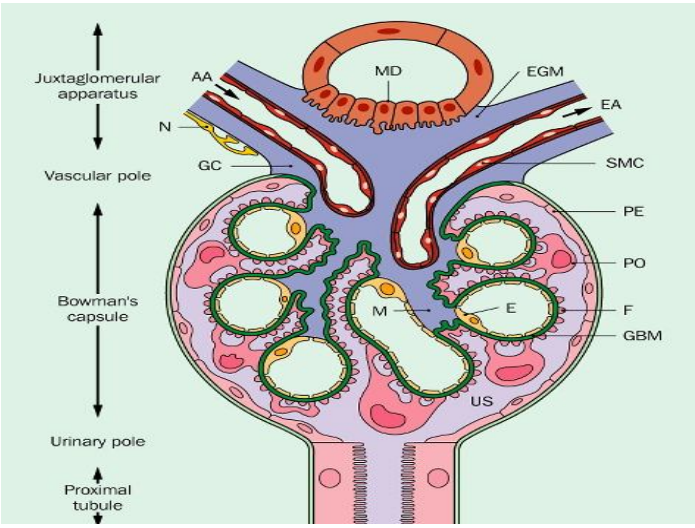


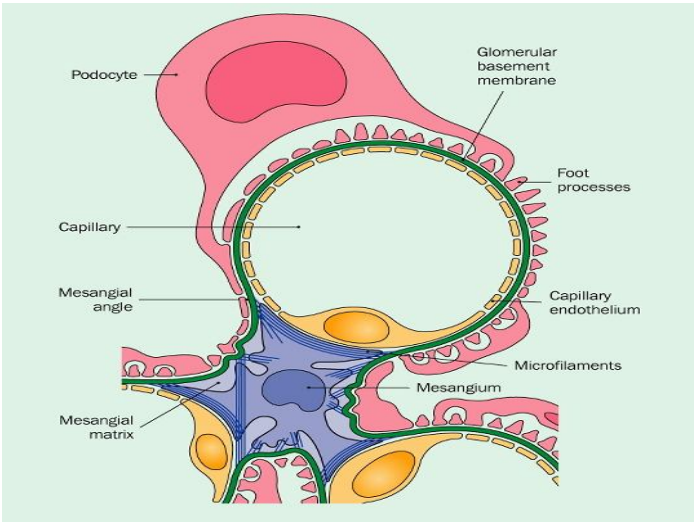
Conclusions:

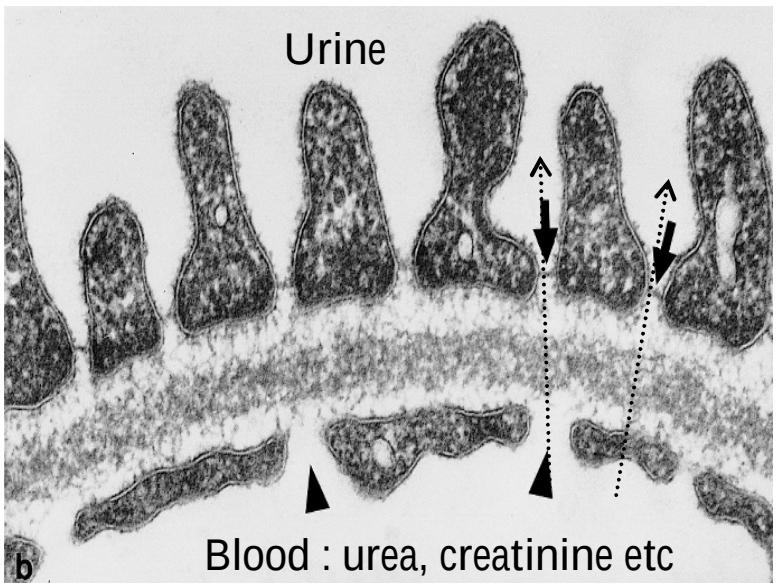
- 3 time /week HD/ HDF minimally acceptable
- Prolonged HD / HDF in any of its form is certainly better both biochemically & clinically
- Patient and cost related factors decide the ultimate choice of therapy
- *The usual time for dialysis is 4 hours, it is found that the longer stay on hemodialysis, the better the advantage for the pts, but the pts can't tolerate staying long time.*

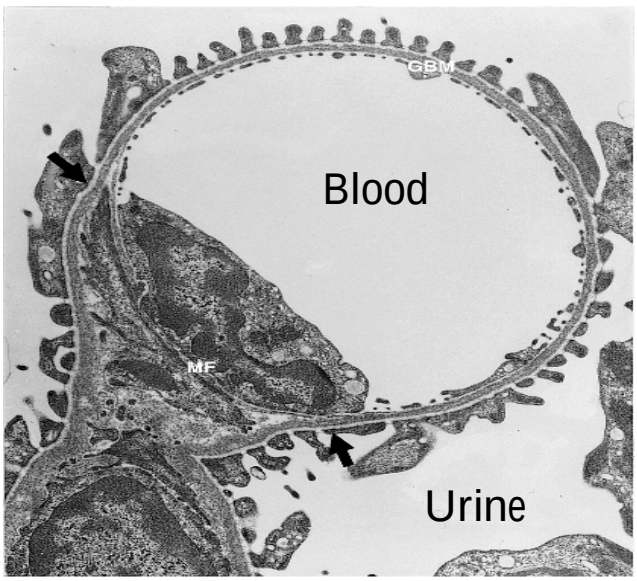
Continuous Renal Replacement Therapy:

- Dialysis continues non-stop for days as needed
- Features:
  - **Blood Flow : low 50 – 120 ml/min**
  - **Dialysate flow : 15 – 30 ml/min [1-2 L /hr]**
  - **UF : 50ml/ hr – 200 ml/hr [1.2 -4.8 L /Day]**
  - **Small Dialyzer**
  - **Modality : Convection, Diffusion**

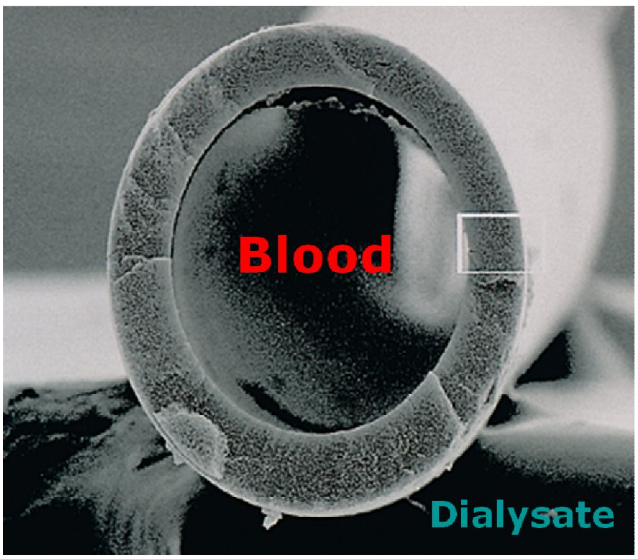


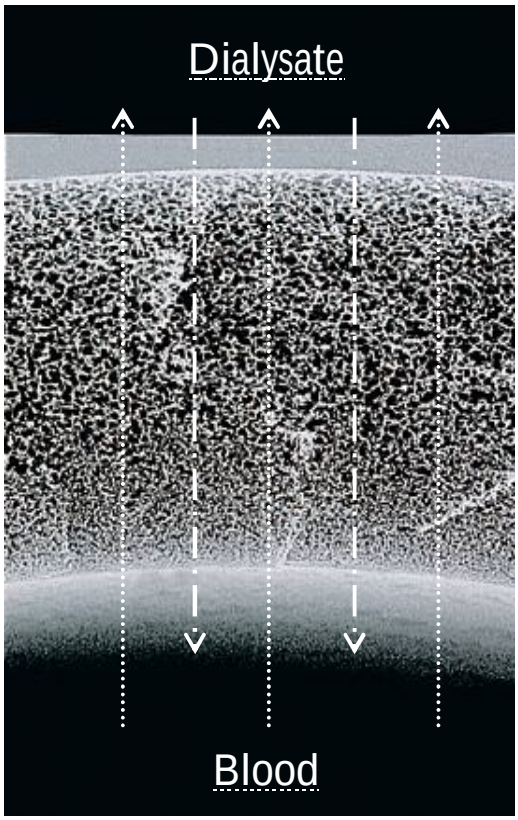






This is what we have made !





Organic compounds accumulate in Uremia:

- Urea
- Creatinine
- Guanidines
- Uric Acid
- Pyridine compound
- Amines
- Phosphate
- homocystine
- Indoles
- Phenoles
- Myoinositol
- Glucoronic Acid
- B2 microglobulin
- Oxalic Acid
- AGE
- Furan carboxylic Acid

Removal of Toxins:

- **Diffusion & convection:**
  - Depends on Concentration gradient across the membrane

Watch the animation on the slides from 49 – 56

If you want to know the mechanism of peritoneal and heamodialysis go to fig.17.23 page 492 in Davidson 20th ed. And page 673 – 677 in kumar 6th ed.

Summary:

We have 2 ways of dialysis :

1- Diffusion
2- Convection

Diffusion: is the process of movement of solutes from a higher to a lower concentration across a semi-permeable membrane. The smaller the molecule, the higher the diffusion.

We use diffusion principle in dialysis process.

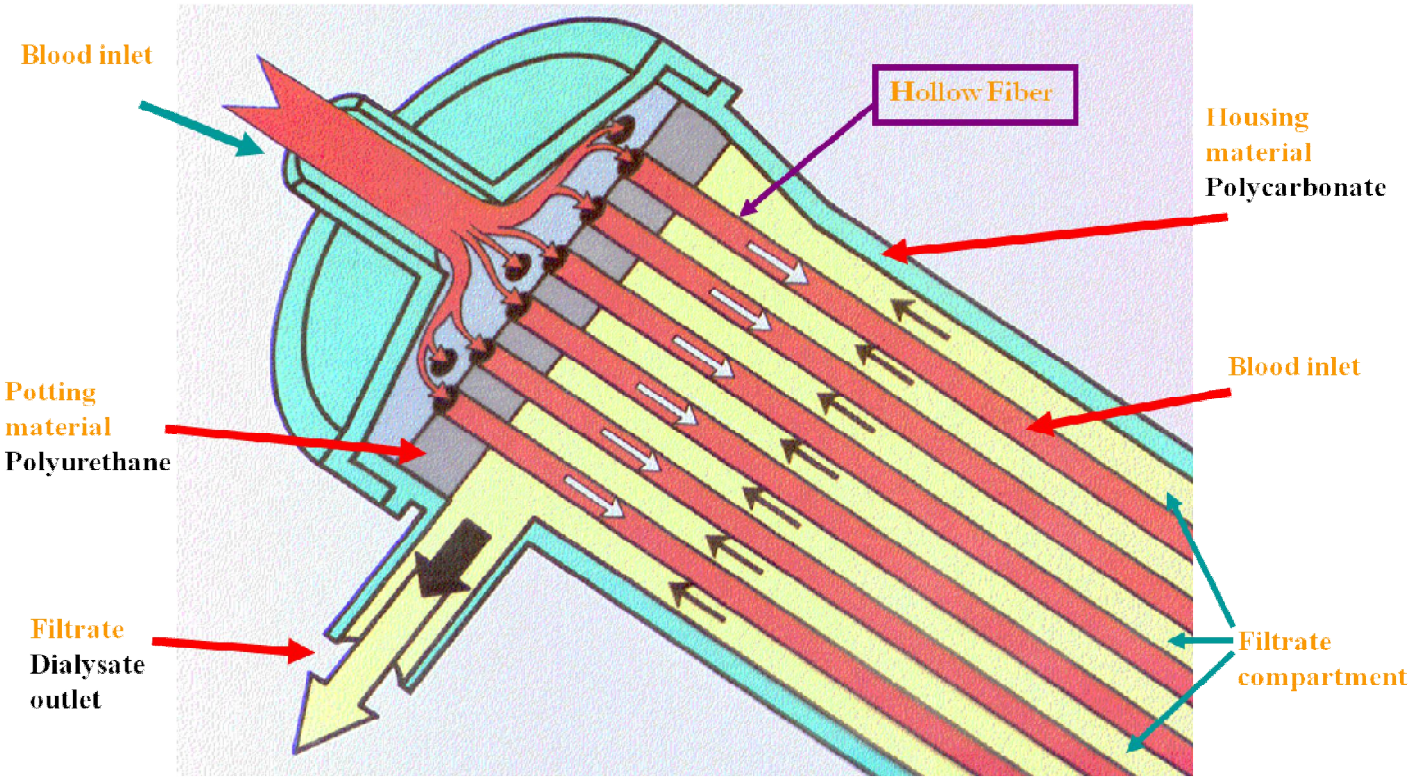
We put semi-permeable membrane and let the blood containing urea in one side and dialysate fluid containing HCO_3 on the other side and let them move in different direction, to make balance between the urea and HCO_3

Convection: is the movement of water across semi-permeable membrane from low concentration area to high concentration area and when it moves, it pulls the solids along with it.

We use convection principle in hemofiltration.

We use both diffusion and convection methods in hemodialfiltration.

Hollow fiber structure:



Dialysate-HD Solution:

- Na 135-145
- K 0- 4.0
- Ca 2.5- 3.5
- Mg 0.5-0.75
- Chloride 98-124
- Bicarbonate 30-40
- Dextrose 11
- pH 7.1-7.3

Replacement Fluid:HF Composition:

- Convection will take away with it, Na, K, Ca, Mg, HCO3 etc
- Composition: Same as the dialysate
- We are kind of infusing the Dialysate directly into the blood!

Dialytic Membrane:

- Cellulose
- Cellulose-Synthetic
- Synthetic

Pore size
Surface Area

Membranes:

- Can be Low Flux :

Low efficiency
High Efficiency

- Can be High Flux :

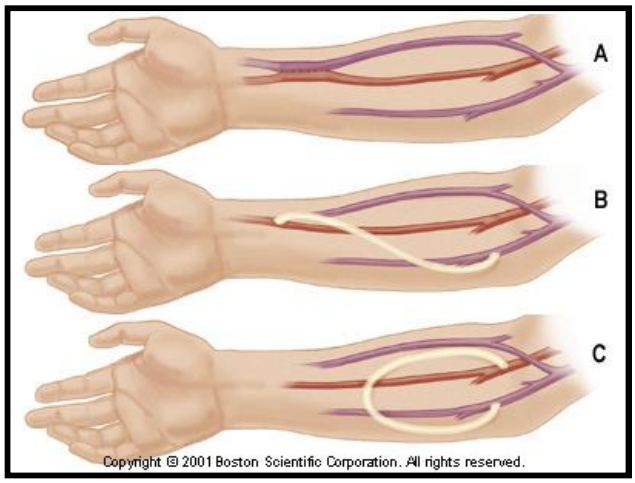
Low efficiency
High Efficiency

High Flux Membrane:

- Larger pores
- Better removal of MM 300-12,000 D
- Hemofiltration [Convection] better than Diffusion.

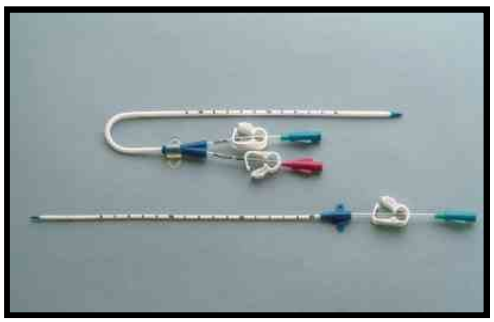
Types of Vascular Access:

- Arterio-Venous **Fistula** – AVF
- Polytetrafluoroethylene PTFE) **Graft**
- **Catheters**
  - **temporary or acute catheters**
  - **chronic or tunneled cuffed catheters**
- Subcutaneous port

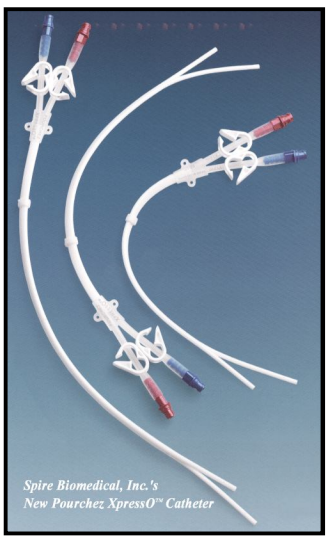


- Double lumen catheter:
  - **Catheter able to provide sufficient blood flow**
  - **11 French and greater**
  - **Avoid kinking**
  - **Secure connections, make them visible**
  - **Right size at the right place**

- Temporary Hemodialysis Catheter:
  - composed of rigid materials such as polyurethane or polyvinyl
  - Suitable for use for a period of days to weeks
  - Blood flow is limited (200 to 250 ml/min)

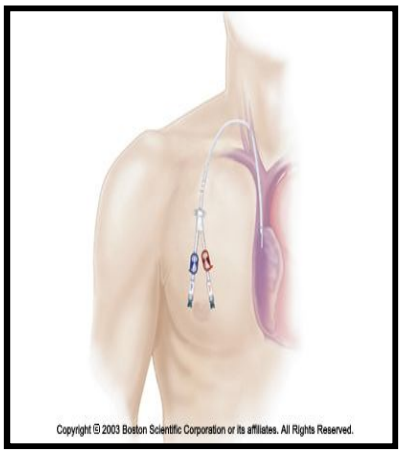


- Tunneled cuffed catheters:
  - Developed in 1987
  - Tunnel and a bonded cuff serve to:
    - » anchor the dialysis catheter in the tunnel
    - » presumably, prevent migration of bacteria down the outer surface of the catheter
  - Soft silastic elastomer



❁ Placement of catheter tip:

– The cuffed tunneled catheter
  » Within the atrium (better flow, less recirculation)
– The temporary non-cuffed catheter
  » The superior vena cava (atrial perforation, arrhythmia)



Catheter related infection:

- Infection is the most prominent and most serious complication
- Increase in metastatic infection and endocarditis

Complications of placement:

- hemothorax (0.6%), hemomediastinum (1.2%)
- pneumothorax (1.8%)
- bleeding that required re-exploration and/or transfusion (4.7%)
- Others: (Arrhythmia, Air embolism, Perforation of vein or cardiac chamber, pericardial tamponade)

★ **The major determinant for problems**:

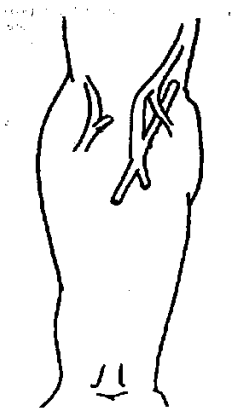
– Use of real-time visualization techniques
– the experience of the operator

Radio-cephalic fistula:

- Gold standard
- Patency rate: 75% at one year .

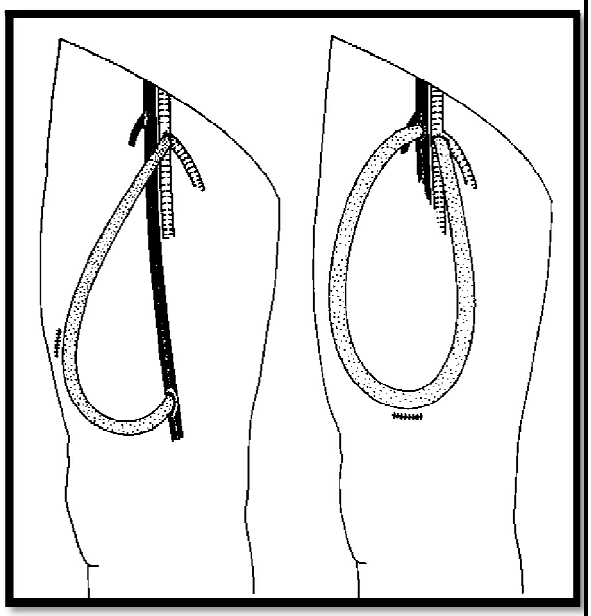
Brachial-cephalic fistula:

- Superior flow & maturation.
- Higher incidence of steal
- 1 year patency 75%
- Favorable in diabetic , women and old patients.
- Revanur et al; 137 fistulas .primary patency rate = 74%



Arterio- Venous Grafts

Femoral PTFE Grafts



AV Grafts:

- PTFE is the material of choice.

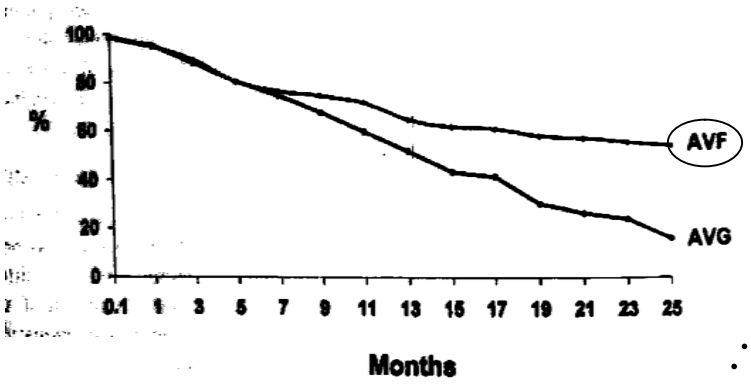
▼ **Advantages:**

- large surface area for cannulation.
- ease in cannulation.
- shorter and more reliable time for maturation.

▼ **Disadvantages:**

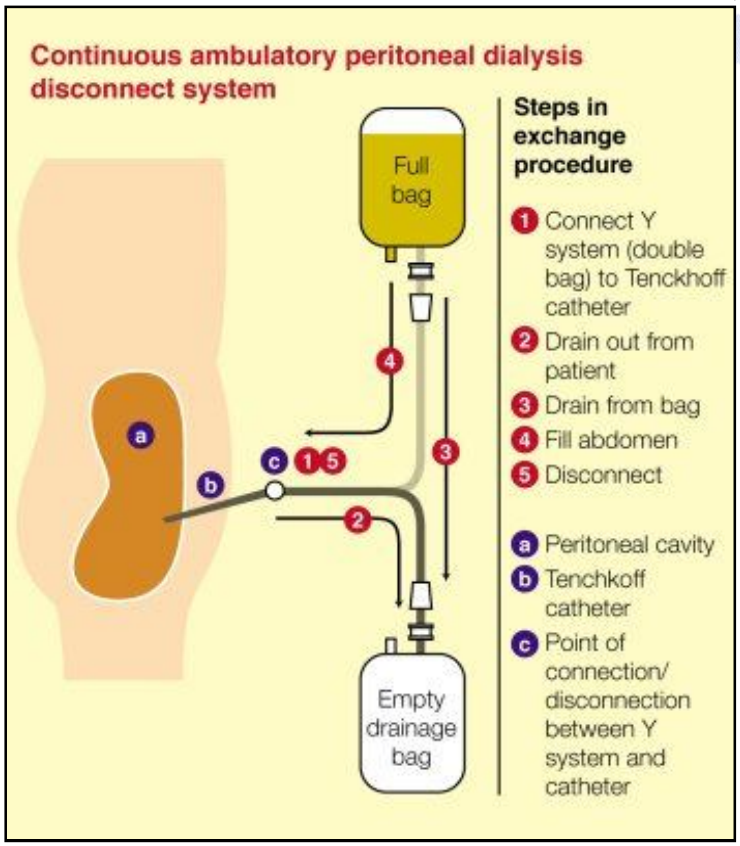
- ↑ risk of infection.
- inferior patency.

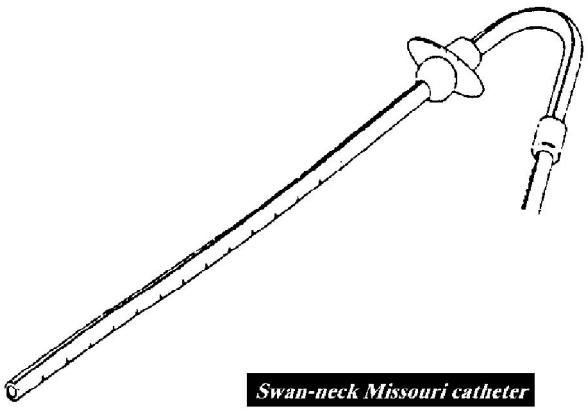
AVF vs AVG



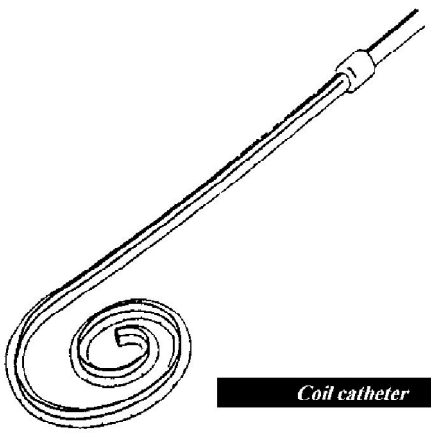
∴ AVF are Superior

CAPD:





Swan-neck Missouri catheter

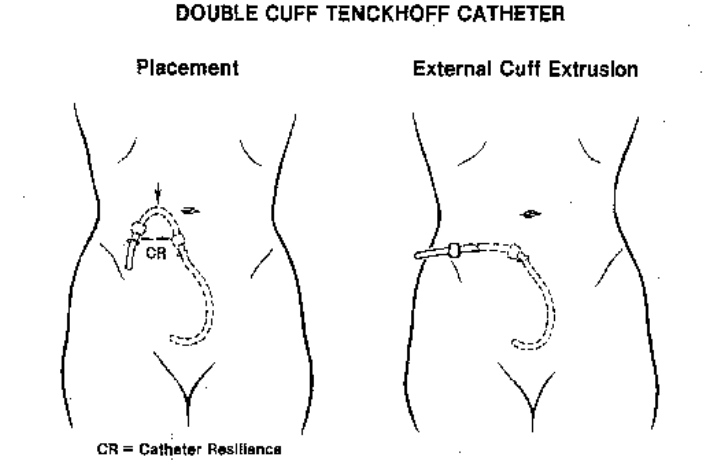


Coil catheter

PLACEMENT TECHNIQUE:

- Blind technique mainly for ARF (7-8%)
- Laparoscopic or peritonoscopic (6%)
  - Less costly
  - Visualize peritoneum
- Open surgery (dissection) standard (85-90)
- Buried technique (rarely used)

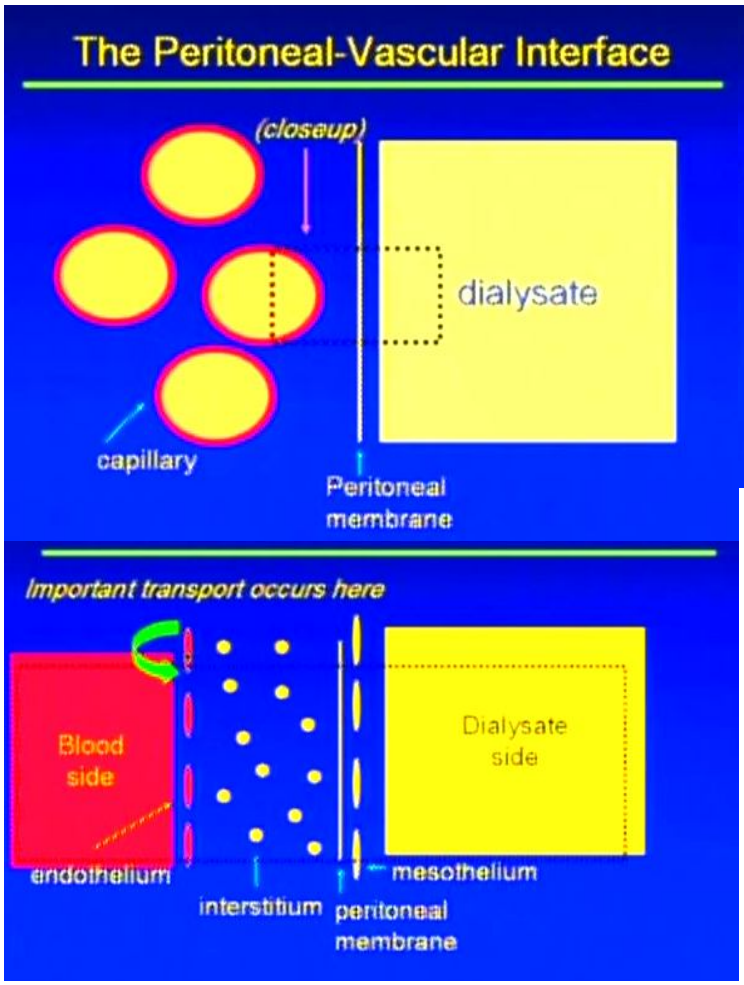
Double Cuff - Straight Catheter

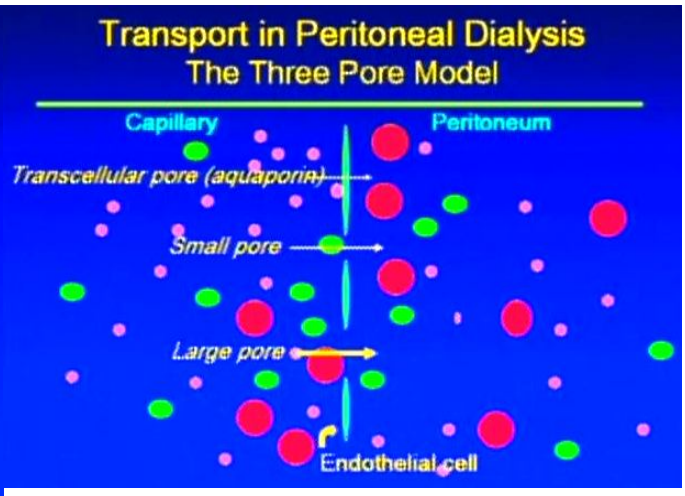


PD Catheter Complications

- Exit site infections (ESI)
  - Morbidity - antibiotic use, patient visits, etc.
  - Risk of peritonitis
  - Risk of catheter loss - (8 - 39% of removals)
  - Risk of transfer to HD - (up to 33% of causes)
- Malfunction - unusual
  - Failure to drain most common problem
- Misc. i.e. erosions, bowel perforation -- rare
  - Leakage
  - Obstruction
  - Evisceration
  - Herniation
  - Tunnel infection
  - Peritoneal fistula
  - Retained cuff*
  - Pseudoaneurysm of epigastric artery

*Late-removal complication: dissection rather than tugging





Solute Transport in PD:

How does solute enter peritoneal fluid?

i. Diffusion
ii. Convection (during ultrafiltration)

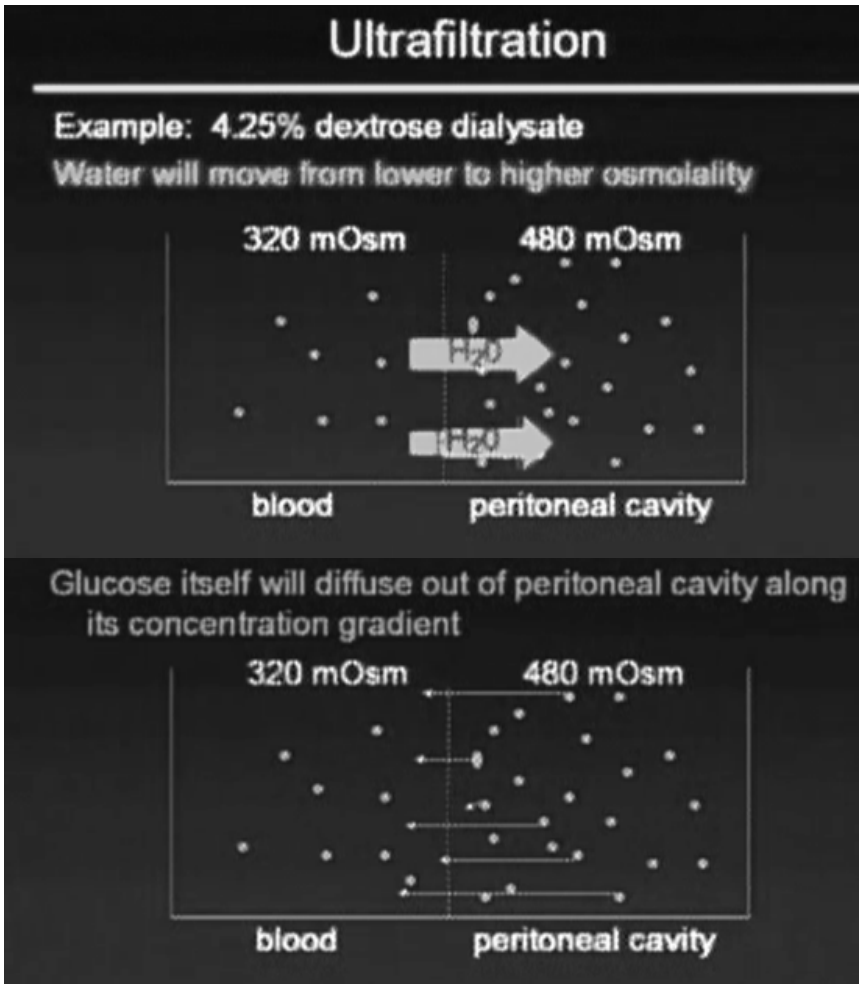
Osmosis = movement of water from area of **low** solute conc. to **high** solute conc.

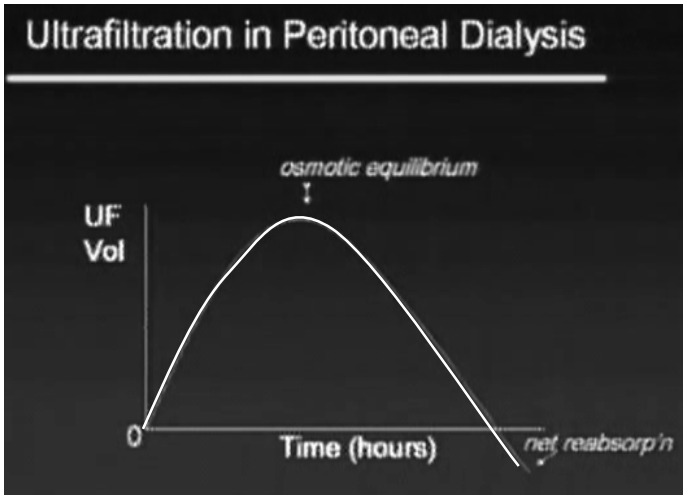
Ultrafiltration in PD:

- In PD, done by *osmotic* pressure (compared to HD where done by *hydraulic* pressure)
- Result of ultrafiltration:
  - Fluid removal
  - Convective removal of solute, especially middle molecules

Composition of Peritoneal Dialysate: Osmolality

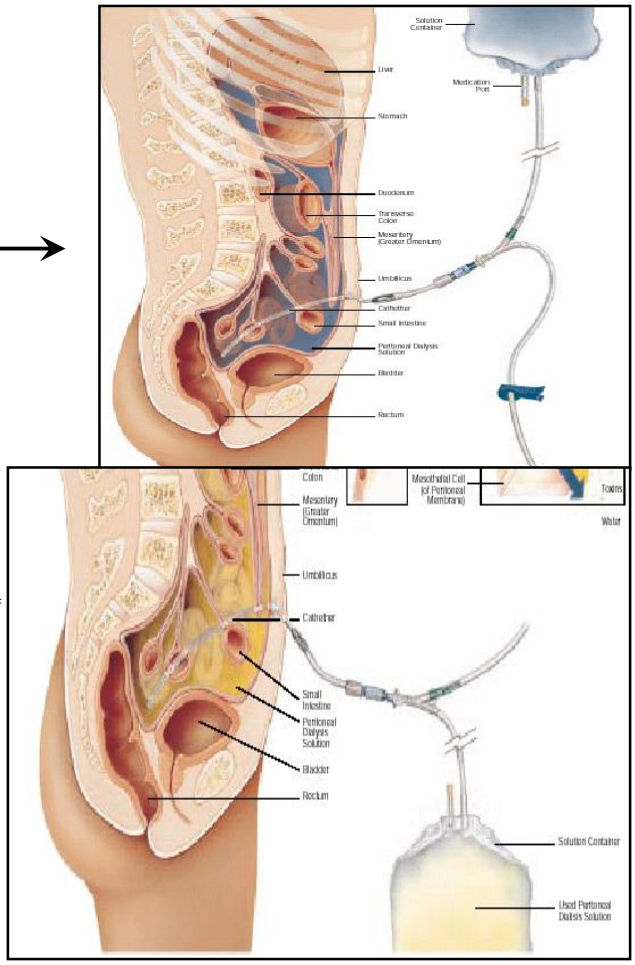
- 1.50% dextrose – 347 mOsm/l (*isotonic*)
- 2.50% dextrose – 397 mOsm/l (*hypertonic*)
- 4.25% dextrose – 485 mOsm/l (*hypertonic*)





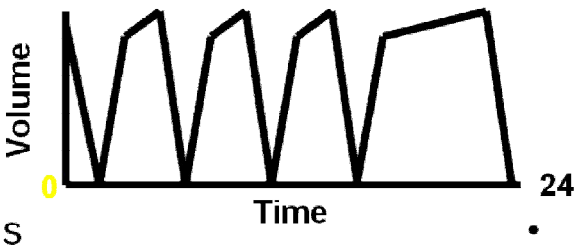
CAPD Exchange Procedure:

1. Fill phase
   (<10 Minutes)
2. Dwell phase
   (4-8 hours)
3. Drain phase
   (<20 minutes)



CAPD

Continuous Therapy



Benefits

- Optimum dialysis for low permeability
- Can be performed anywhere

Ambulatory

Anywhere

4 - 5 Exchanges

Long Dwells

Limitations

- Rapid transporters will have poor UF
- 4 x exchanges per day
- IP pressure with large volumes

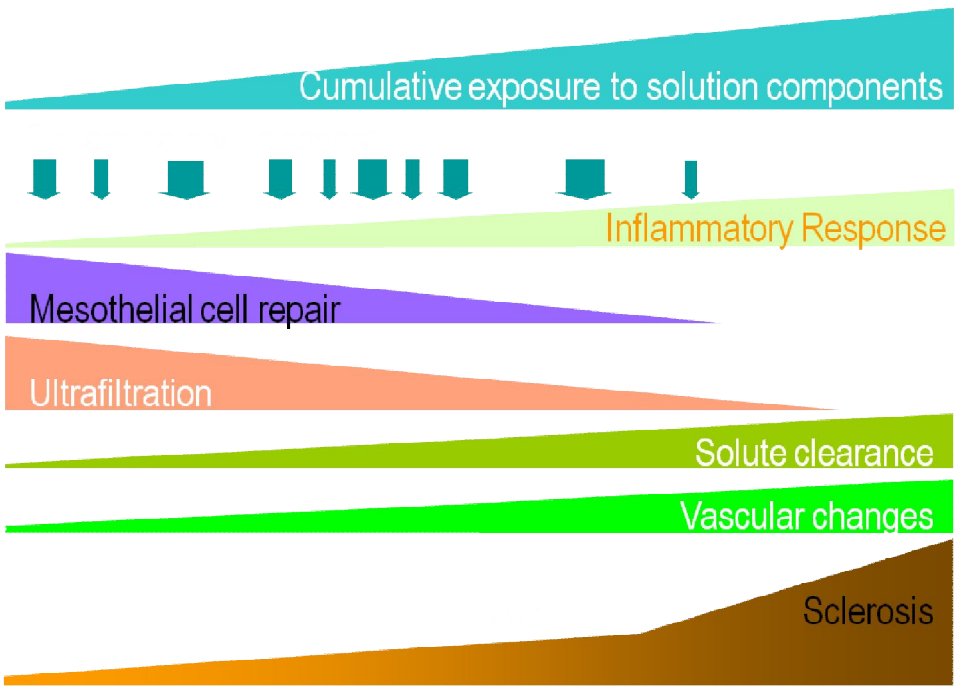
CAPD - basic prescription:

- Manual therapy
- Prescription volumes standardised :
  1,500ml, 2000ml, 2500ml, 3000ml solution bags
- 6-8 hour dwell period each night (depends on type of membrane)
- 4-5 day exchanges (with optional night dwell), 7 days a week
- 3-5 hr dwell per day exchange

UNPHYSIOLOGIC 'NON-BIOCOMPATIBLE' NATURE OF PD SOLUTIONS:

- High glucose content
- Low pH
- Hyper-osmolarity
- High lactate level
- High GDPs
  - » Glucose degradation products
- Generate AGEs
  - » Advanced glycation endproducts

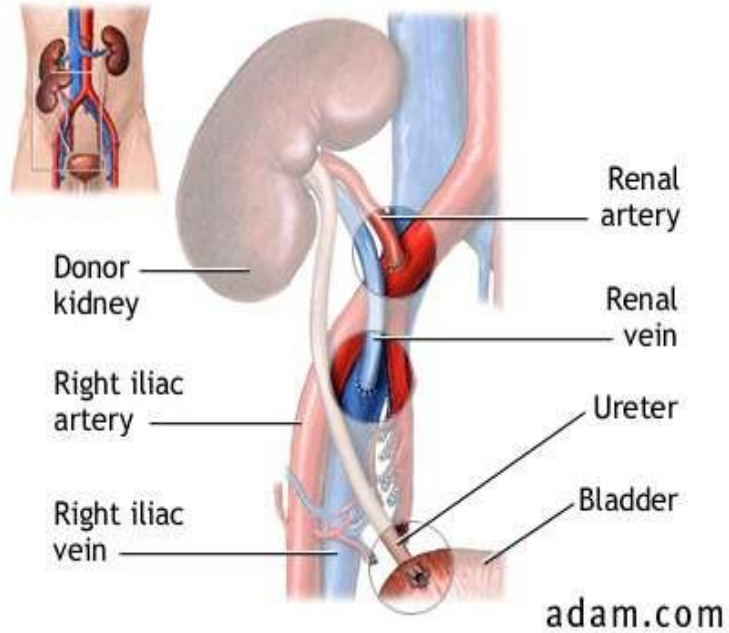
Long Term Membrane Viability A Working Hypothesis:



PD Technique Survival:

- **Reasons for withdrawal**
  - Loss of UF
  - Inadequate dialysis
  - Peritonitis
  - Patient choice/psychological ('burn-out')

Renal Tx:



Renal Transplantation (FACTS):

- Survival of patients and grafts has improved tremendously over the last twenty years due to (better surgical techniques and immunosuppression)
- In comparison to dialysis, transplantation is a less expensive and better rehabilitative method of renal replacement therapy and provides better quality of life

Renal Transplantation in the Kingdom of Saudi Arabia:

First renal transplantation : 1979
This was done using a living related donor.

Sources of donors:

- Cadaver donors (Brain dead,non-heart beating)
- Living related (genetically, emotionally)
- Xenografts

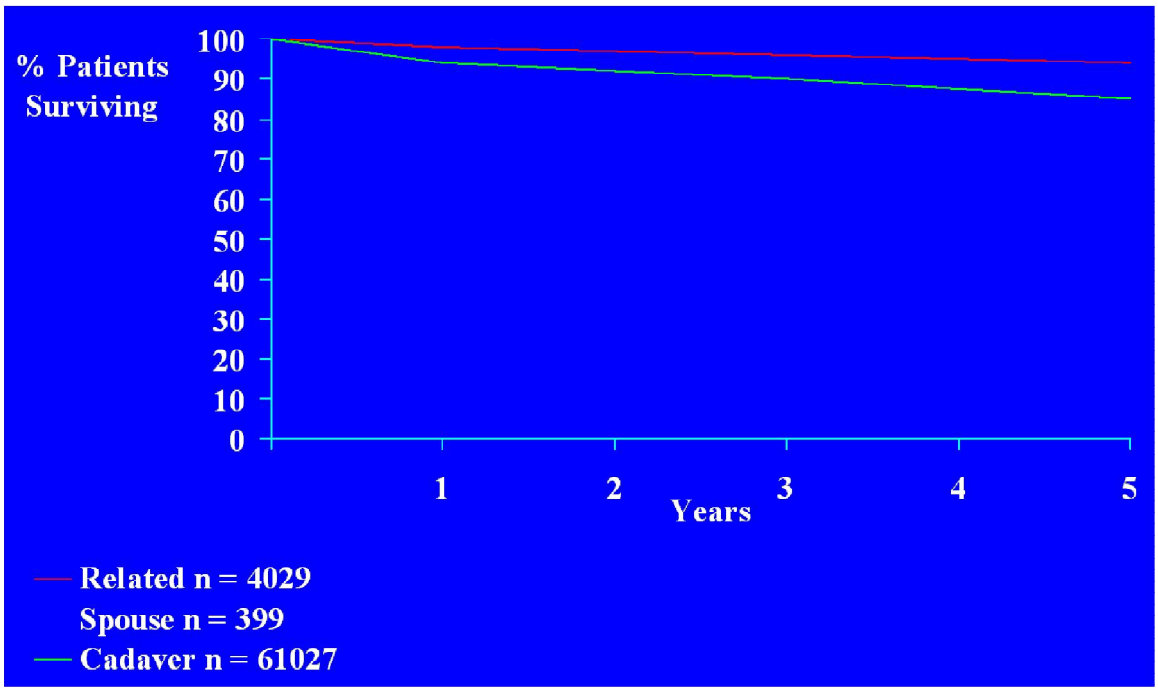
PRE-TRANSPLANT EVALUATION:

- Preferred treatment modality – ESRD
- Improved quality of life – vs HD/PD
- Vast & expanding shortage of cadaver donor organs
- Wait for 3 – 4 Yrs
- If Living donor organ → 2 -3 months
- Diabetics – Pre-emptive transplantation
- Avoids CVS complications – Volume shifts of dialysis
- Identify medical & surgical issues
- High risk – PO & longterm complications
- **Transplant committee**
- Transplant Nephrologist
- Donor Nephrologist
- Transplant surgeon
- Histocompatibility experts
- Transplant nurse coordinator
- Social worker

ABSOLUTE CONTRAINDICATIONS:

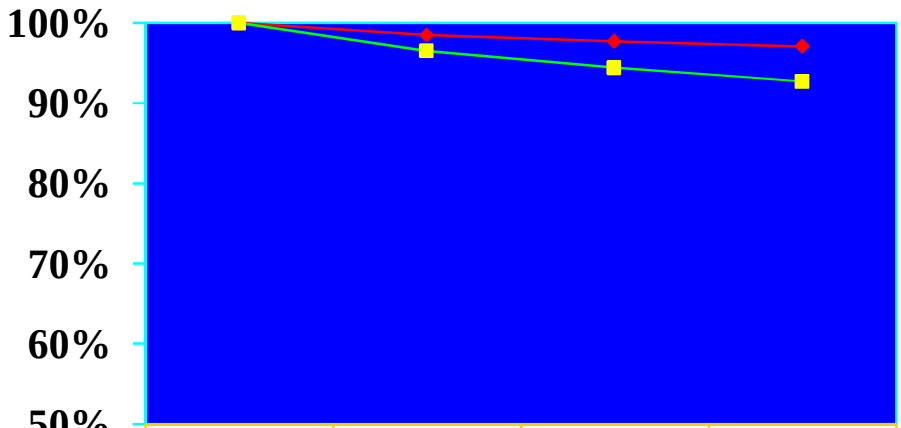
- ★ Life expectancy < 5 Yr
- Recent malignancy
- Active infection
- HIV infection
- Chronic untreated infection
- Uncontrolled psychiatric disorder
- ABO blood group mismatch
- Positive cross match

Patient Survival With a Renal Graft in Europe (1987 – 1997):



Source: Collaborative Transplant Study Registry, Prof Opelz, Heidelberg
Nephrol Dial Transplant Vol 15 (2000) Suppl 7 P 83

Renal Transplantation in KSA (Living Related):



	0	1	2	3
Patient Survival	100%	98.5%	97.7%	97.1%
Graft Survival	100%	96.5%	94.4%	92.7%

.: The End :.

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